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Hubbard Brook
Experimental Forest

A Research Facility of the
Northeastern Forest Experiment Station
Forest Service, U. S. Department of Agriculture
1964

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WELCOME TO HUBBARD BROOK EXPERIMENTAL FOREST

THIS booklet describes some of the major water problems in the mountainous forested regions of New England and introduces you to the Hubbard Brook Experimental Forest near West Thornton, New Hampshire, where watershed research is being conducted to find out the basic facts of how and why our forested watersheds behave as they do and how the water resource is and can be affected by forest management.

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WATER IS THE lifeblood of all living things. History shows that the failure of some ancient civilizations can be traced to unwise use of the land, forest, and water resources. These three resources interact in complex and delicate ways; and how we manage them may well determine how we as a nation survive and thrive.

Forested watersheds in mountainous terrain are the headwaters for all the major rivers in New England. Forest practices on these watersheds may strongly influence the usefulness of the water resource in downstream regions. Downstream users are placing increasingly heavy and diversified demands upon this water. It is used by industries and municipalities, serves as a source of hydroelectric power, provides for navigation, and serves as a waste-dispersion agent. And fresh, clear water for wildlife and recreation is rapidly becoming a prime necessity.

The Water Problem

NEW ENGLAND'S water problems can be considered in three broad classes: low flows, floods, and water quality.

Low Flows

Although the region is endowed with 40 to 50 inches of precipitation per year, equally distributed among the months, streamflow is unequally distributed. By late summer and early autumn, when the demand for water is the greatest, streamflow usually has dwindled very low. For example, in the White Mountains of New Hampshire, flow during August amounts to only 0.2 percent of the annual flow. Little summer rainfall reaches the stream channel. Most of it evaporates from the ground or water surfaces and transpires from the leaf surfaces of trees. The low flow problem might be alleviated partly by reducing the number of trees, by introducing species that have lower water requirements, and by temporarily defoliating the trees or closing the leaf pores.

Floods

Flood potential increases in spring when the water from the melting snowpack combines with heavy rainfall, possibly on frozen ground, bare rock, or other impermeable surfaces. In the White Mountains, 37 percent of the annual flow comes in April, the month of maximum snowmelt runoff. The timing of the snowmelt is a critical factor in flood reduction. Melt can be delayed or advanced by altering the composition of the forest, its density, and the patterns of openings with respect to the direction of the sun's rays. Surface permeability can be influenced by land-uses and by the characteristics of the organic deposits on the surface.

Although floods are a threat each spring, some of the highest flood flows in this region happen in the fall, when there is no snow. Such flood flows indicate: (1) soils with high porosity and low moisture storage, in this case shallow soils with high rock content; and (2) steep slopes and stream channels. Moderate rainfall quickly recharges these soils. All excess water moves rapidly below the surface until it reaches the stream channels, where the flow rises and falls sharply — much like rain from a tin roof. This poses one of the hardest problems for watershed management and will require considerable research effort.

Water Quality

Water quality becomes an ever more important problem as the complexity of water use increases in this region. Timber harvesting and road construction, if improperly done, can severely damage water quality. Rains can carry exposed mineral soil from roads, banks, and skid trails directly into stream channels. If these sediments remain in suspension, downstream uses of the water are restricted because of lowered quality. Deposits of larger particles — sand, gravel, and boulders — cover the feeding and spawning grounds of fish, and fill in small lakes and reservoirs. Water quality is also related to water quantity. When streams are low, there may not be sufficient water to transport or dilute normal amounts of waste products. Then the pollutant overbalances the diluent.

Meeting the Problem

TO seek solutions for these problems of forested watersheds in New England, the Hubbard Brook Experimental Forest was established in 1955 in the White Mountains of New Hampshire by the Northeastern Forest Experiment Station. One of a number of U. S. Forest Service installations for research into watershed problems, the Hubbard Brook unit has responsibility for research on forested mountainous watersheds in the six New England states. A staff of professional investigators conduct research here in soils, hydrology, climatology, and allied disciplines. The field headquarters is located 1 mile west of U. S. Route 3 in West Thornton, New Hampshire.

Three phases of research are involved in the program at Hubbard Brook:

1 The first phase consists of an inventory and assessment of all the pertinent components of the hydrologic cycle; that is, the disposition of water as it travels through the cycle in a forest environment. This requires detailed measurements of rain and snow, the primary source of water in the cycle; of solar radiation, the origin of energy for water loss through evaporation and transpiration; of soil and underlying strata, the medium and pathway for subsurface water storage and movement; of forest cover, the user of water from the soil and the distributor of water to the atmosphere; and of streamflow, the residual after all other water-demanding components have taken their toll.

To obtain such information a variety of devices are employed, ranging from stream-gaging stations the size of a swimming pool down to thermocouples the size of a needle for measuring temperatures of leaves. These sensitive instruments must operate in remote areas subject to a rigorous climate.

Daily records of precipitation and streamflow are collected on a number of small experimental watersheds for 6 to 8 years. During this period streamflow behavior is determined over a wide range of climatic conditions, and comparisons are made

among several watersheds. The watersheds then are ready to test the effectiveness of forest treatments.

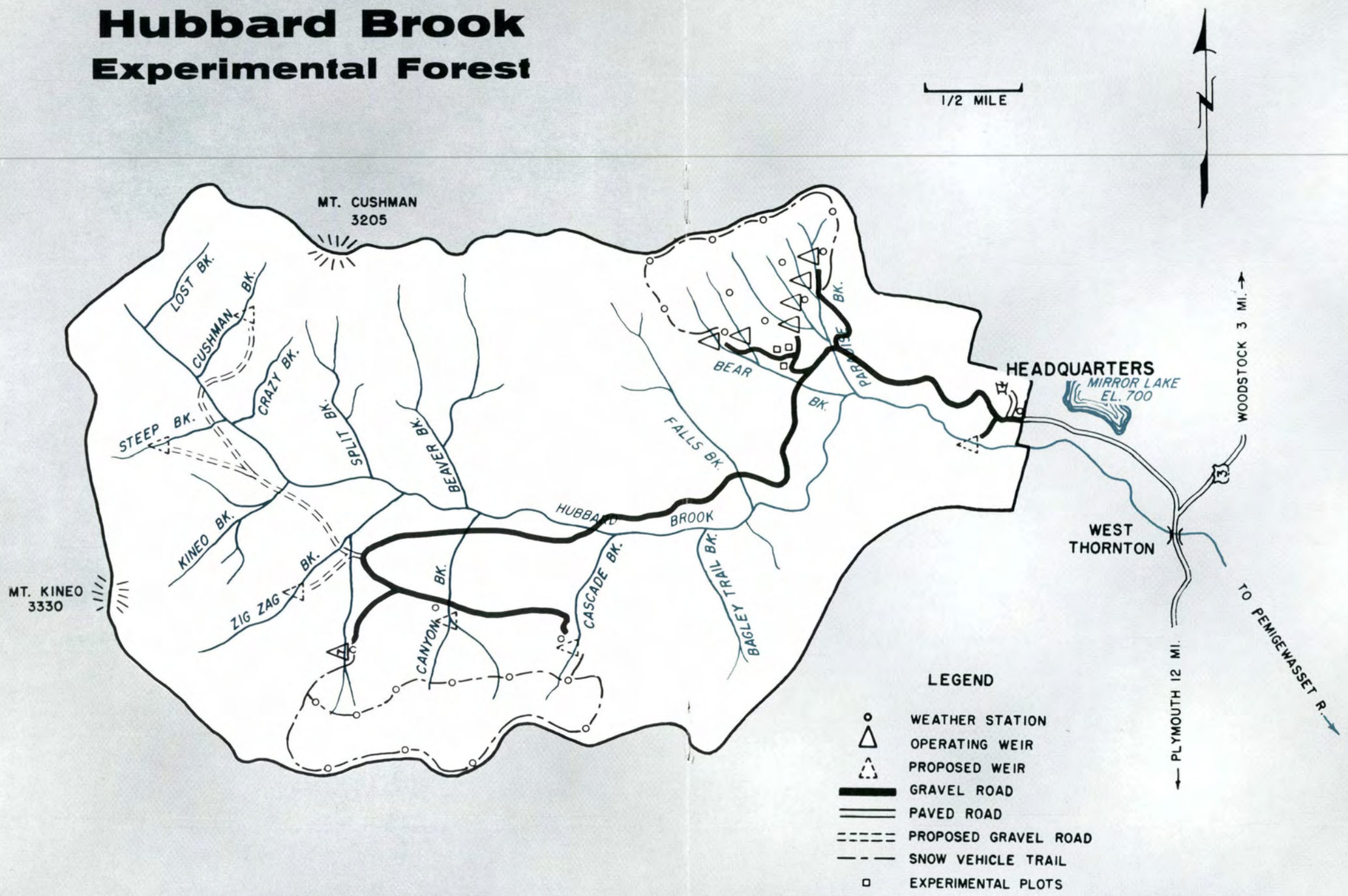
Complementing the experimental watersheds, small plots are used to obtain more sensitive observations of the hydrologic components for specific topographic and forest situations.

2 The second phase of the research program consists of altering the forest vegetation on these small watersheds and determining what happens to streamflow afterward. Several types of treatments are contemplated. To increase flow during summer and early autumn, complete or partial removal of forest cover will be tried. Conversion of a forested watershed (or parts of it) to other species that demand less water will be tested. Perhaps defoliation of trees or closure of leaf pores by a non-injurious chemical spray might produce an immediate, short-term increase in streamflow. If changing the timing of snowmelt runoff is the objective, then treatments involving variously oriented strip cuttings or coniferous plantings might be tried to delay melting. Evaluating the effects of treatment also includes appraising the changes in water quality, particularly turbidity and temperature. In this phase, the effects of treatment are compared to streamflow conditions on a control watershed that is kept in an undisturbed condition.

3 The final phase of research is to translate the single-treatment effects from small experimental watersheds and plots to the effects of multiple-treatments employed in management of much larger watersheds. This requires intensive research to determine just where and how the effects come about on the experimental areas, comparative studies of streamflow from experimental and larger managed watersheds within the region, and from them, the predicting and testing of treatment effects in practice.

The tying-together of the plot, experimental watershed, and regional studies is the ultimate research job. We hope it will produce what the forest land manager wants — reliable information to help him predict what the streamflow response will be if he treats the land in a certain manner.

Hubbard Brook
Experimental Forest



The Experimental Forest

THE Hubbard Brook Experimental Forest is a bowl-shaped 7,600-acre tract of federally owned forest land in the White Mountains of New Hampshire. Numerous small tributaries, draining areas of 20 to 400 acres, flow into Hubbard Brook. This in turn flows into the Pemigewasset River at West Thornton. The watershed is about 5 miles long and 3 miles wide. Elevations range from 750 feet to 3,330 feet (Mt. Kineo). Much of the terrain is steep and rugged. Watershed boundaries are well defined by ridges and valleys.

Hubbard Brook was selected for intensive watershed research because (1) it has relatively uniform topography, geology, soils, climate, and vegetation; (2) virtually no forest disturbance has occurred for the past 50 years; (3) there are many small gageable streams in a relatively small area; and (4) the area is characteristic of much of the White Mountains in particular and generally like the mountainous terrain of New England.

Work has begun here by establishing a number of small plot studies and stream-gaging and weather stations; and developing a physical plant with necessary roads, trails, and buildings.

Geology

The surficial features of Hubbard Brook are geologically very young — only about 11,000 years old. During the last glaciation the surface of the consolidated bedrock (gneiss, schist, and granite) was scoured and honed smooth. Most of the original soil that was formed prior to glaciation was carried away by the mile-thick glacier as it ground over the existing mountains in a northwest-southeast direction.

Materials deposited by the glacier as it receded were highly variable in size — particles ranging in size from clay to large boulders. Depths of deposits also varied—from complete absence of material on the ridge tops and rock outcrops to 30 feet or more in the valleys.

For geologic reasons alone, the tributaries of Hubbard Brook

are ideally suited for watershed research. They are natural watertight basins. The bedrock is tight, having few fissures; and these diminish rapidly with depth; thus there is negligible deep seepage. Also, the relatively sharp watershed boundaries prevent the escape of water.

Soils

Soils at Hubbard Brook are predominately well-drained podzols derived from glacial till of igneous origin, giving rise to sandy loam textures. Principal soil series are the Hermon (most extensive), Becket, Waumbec, Canaan, Berkshire, Peru, Leicester, and Colton. These soils are acid (pH about 5.0 or less) and infertile. Except where the soil surface has been disturbed by windthrown trees, a 2- to 6-inch-thick humus layer is present. This layer permits rapid infiltration of water and protects the soil from freezing before snow accumulates in winter.

Soil depths average about 5 feet. The separation between the soil mantle and the virtually unweathered bedrock below is distinct. Rocks of all sizes are scattered throughout the soil profile. In many places boulder fields are prominent features.

Because of the shallow depths, coarse sandy textures, and high rock contents, these soils have low water-storage capacities, high porosity, and quick drainage. These soil characteristics are reflected by the rapid response of streamflow to rainfall.

Climate

Though Hubbard Brook is only 72 airline miles from the Atlantic Ocean, the climate is dominantly continental. Annual precipitation is about 48 inches, of which about one-third to one-fourth is snow. This precipitation, on the average, is equally distributed among the months of the year. Approximately 140 separate storms occur per year, or almost 3 storms per week. Snow usually persists from mid-December till mid-April, with a peak accumulation in March of about 40 to 50 inches, having about 10 to 12 inches of water content.

Winters are long and cold. January averages 16° F. and long periods of low temperatures from 0 to 10° F. are common. In spite of the cold temperatures, occasional mid-winter thaws occur, when the snow pack may be wholly or partly melted, thereby bringing the streams to near flood stages. Short cool summers are the rule. The average July temperature is 66° F. The average number of days without killing frost is 110; however, the growing season for trees is considered to be from May 15 (approximate time of full leaf development) to October 15 (leaf fall).

Vegetation

The area is entirely forested, mainly with deciduous northern hardwoods: beech, birch (yellow and white), and maple (sugar and red), and some white ash. Other less abundant species are trembling aspen, mountain maple, and striped maple. On the ridges and rock outcrops, along the main Hubbard Brook, and in scattered pockets, conifers such as red spruce, balsam fir, and hemlock are present. Logging operations about 1910 removed large portions of the conifers and some of the better quality accessible hardwoods. The present second-growth forest is unevenaged, composed of about 80 percent hardwoods and 20 percent conifers.

Research Facilities

ONE of the most important parts of the research program at Hubbard Brook is accounting for the water budget; that is, determining quantitatively the various components of the hydrologic cycle. Therefore, most of the research installations are geared to measure these components.

Experimental Plots

Research on specific hydrologic components usually requires intensive investigation of environmental conditions on small areas. Several areas have been established for this purpose where many of the variables affecting evapotranspiration, such as the heat budget, other climatic phenomena, and vegetative cover conditions, are being investigated. An example of the instrumentation used is a 72-foot tower erected through and above the forest canopy without disturbing it. A wide variety of instruments

are hung on this tower to detect climatic changes such as moisture, heat, and light throughout the forest profile.

Experimental Watersheds

To test on a watershed basis the relationships between forest cover or other land uses and precipitation and streamflow, several experimental watersheds have been established. These range in size from 30 to 185 acres. Eventually a total of about a dozen will be gaged, including the entire 7,600-acre Hubbard Brook drainage.

The amount of precipitation falling in these watersheds is determined by a network of rain gages scattered throughout each watershed so that there is about one for every 32 acres. Automatic recorders register the amount and time of precipitation in each storm.

Streamflow is measured at stream-gaging stations at the foot of each experimental watershed. A stream-gaging station consists of a small concrete dam, sometimes combined with a metal flume, to direct all streamflow through the measuring section. Water flowing through the gage is measured by automatic recorders, day by day, summer and winter.

Improvements

Several buildings on the Experimental Forest serve as an office, field laboratory, quarters for summer field assistants and a resident superintendent, workshop, garage, and storage. Facilities are also available in Laconia, New Hampshire, at our Watershed Project headquarters, for conducting detailed laboratory investi-

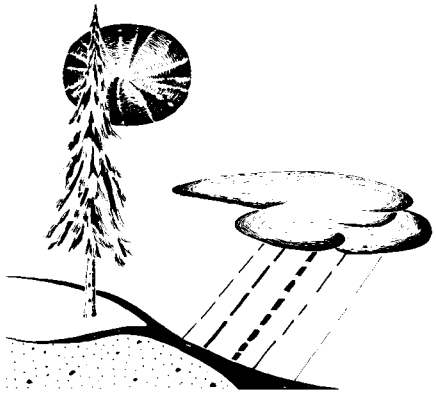
gations. Access through the forest is provided by a main gravel road and spur roads to stream-gaging sites and experimental plots. A foot and snow vehicle trail system connects the scattered network of precipitation stations.

Research Results

RESEARCH so far conducted at Hubbard Brook has involved soil erosion from logging roads; revegetation of skid trails; soil frost, snow depth, air temperature, and soil moisture infiltration relationships; litter accumulation and humus formation; interception of precipitation by vegetation; and snow melt-streamflow relationships.

Cooperation with other Federal agencies, state organizations, educational institutions, and other interested groups has enabled this project to widen the scope of its research program and thus provide results unattainable by independent research.

Results of investigations are published from time to time in Forest Service series, scientific journals, and in popular periodicals. For detailed information write: Director, Northeastern Forest Experiment Station, 102 Motors Avenue, Upper Darby, Pennsylvania, or Project Leader, Watershed Management Research, Northeastern Forest Experiment Station, Laconia, New Hampshire.



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